Electron-beam induced carbon nanomasking for selective electrodeposition of metals on Si(100)

T. Djenizian*, L. Santinacci**, P. Schmuki*
* Dept. of Material Science, LKO, University of Erlangen-Nuremberg,
Martenstr. 7, D-91058 Erlangen, Germany.
** On leave from, EPFL Lausanne, Dept. of Materials Science, LTP, Switzerland

During past decades, there has been a great deal of interest in micro- and nanometer scale pattern generation on semiconductors. The field is particularly driven by semiconductor technology and its continuous demand for shrinking dimensions in the development of established and novel devices. Except for UV lithography, electron beam (e-beam) lithography is currently one of the most employed approaches to obtain high resolution patterning on one hand to fabricate photolithographic masks on the other hand to create ultrasmall linewidths on both silicon and silicon dioxide.

Additionnaly, a number of studies deals with e-beam induced deposition reactions: the precursor molecules present or introduced into the vacuum chamber of a scanning electron microscope (SEM) decompose under the direct electron bombardment and form a deposit on the substrate surface. A specific case of e-beam induced patterning is the formation of carbon rich contamination layers in scanning electron microscopes (SEMs). The e-beam activates reactions of the residual hydrocarbons molecules issued from the pump oil to form a deposit with mechanical and electrical properties close to diamond (*i.e*: the deposits are electrically insulating).

In previous own work, it has been demonstrated that e-beam induced carbon deposition acts as a negative resist for electrodeposition of gold [1,2] and CdS [3]. The present work explores possibilities to extend the use of C-masks produced by contamination writing in a SEM to suppress selectively various metal electrodeposition reactions at C-treated surface locations. Carbon contamination lines were written at different electron doses on n-type Si(100) surfaces. Subsequently copper, gold and palladium were electrochemically deposited on e-beam patterned surfaces. The carbon masks as well as the metal deposits were characterized by SEM, atomic force microscopy (AFM) and scanning Auger electron spectroscopy (AES). We demonstrate that carbon deposits in the order of 1 nm thickness can be sufficient to achieve a negative resist effect, *i.e*: can block the electrodeposition of metals completely selectively. The lateral resolution of the process is in the sub 100 nm range. The nucleation and growth of metal deposits and their morphologies as well as the selectivity and resolution of the process depend on several factors such as the electron dose during masking, and the applied potential and polarization time during metal depositions.

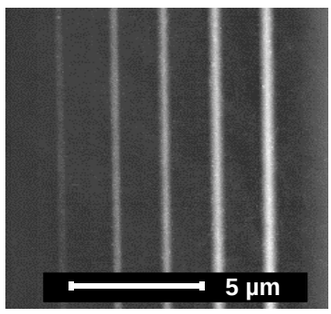

Fig.1: AFM top view of an array of five contamination lines, e-beam deposited on silicon with 10, 30, 60, 120 and 180 s exposure time (the e-beam exposure time increases from the left to the right).

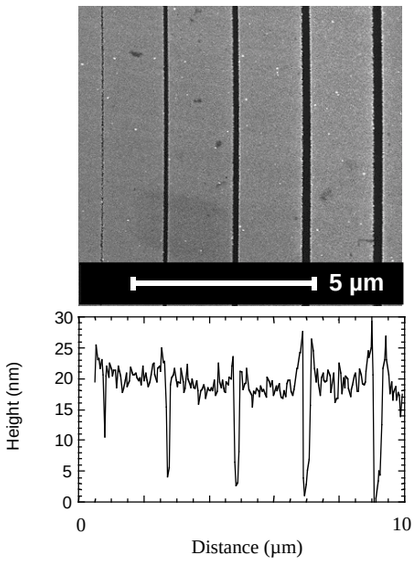

Fig.2: SEM image and AFM profile of Au deposit on Si surface carrying the C-line pattern of Fig.1.

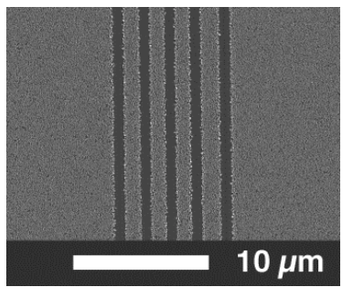

Fig.3: SEM image of a Cu deposit on a Si surface carrying a C-line pattern.

References:

[1] T. Djenizian, L. Santinacci and P. Schmuki, *Appl. Phys. Lett.*, in press, 2001.
[2] T. Djenizian, L. Santinacci and P. Schmuki, *J. Electrochem. Soc.*, **148**, C197 (2001).
[3] T. Djenizian, L. Santinacci and P. Schmuki, *Electrochim. Acta*, submitted, (2001).